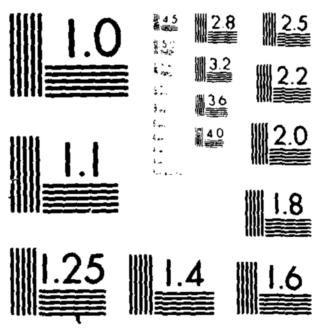
AD-A097 082   ARMY ELECTRONICS RESEARCH AND DEVELOPMENT COMMAND WS--ETC F/G 4/2
EVALUATION OF A TETHERED KITE ANEMOMETER.(U)
FEB 81 K E KUNKEL
UNCLASSIFIED ERADCOM/ASL-TR-0076 NL

1 OF 1
AD
A097082

END
DATE
FILMED
9-81
DTIC



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963 A

LEVEL II

(12)

ASL-TR-0076

AD

Reports Control Symbol
OSD-1366

AD A097082

EVALUATION OF A TETHERED KITE
ANEMOMETER

FEBRUARY 1981

By

Kenneth E. Kunkel

US Army Electronics Research and Development Command
ATMOSPHERIC SCIENCES LABORATORY
White Sands Missile Range, NM 88002

NOTICES

Disclaimers

Disposition

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ASL-TR-0076	2. GOVT ACCESSION NO.: AD-A097	3. RECIPIENT'S CATALOG NUMBER: 082
4. TITLE (and Subtitle): (6) EVALUATION OF A TETHERED KITE ANEMOMETER		5. TYPE OF REPORT & PERIOD COVERED: (9) Final Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): (10) Kenneth E. Kunkel		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM 88002		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: (16) DA Task 1T161102A91A-09 (17)
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Electronics Research and Development Command, Adelphi, MD 20783 (11)		12. REPORT DATE: February 1981
		13. NUMBER OF PAGES: 16 (12) 34
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): (14) ERADCOM/ASL-TR-0076		15. SECURITY CLASS. (of this report): UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Anemometer
Wind profile
Boundary layer

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A kite anemometer which can obtain windspeed and wind direction in the range of 3 to 40 ms^{-1} up to heights of 500 m has been tested for potential Army applications. It has been found to be inexpensive, portable, easy to use, and able to operate under strong winds (up to 40 ms^{-1}). Wind profiles using the kite anemometer were measured at a mountaintop location. These profiles demonstrate the ability of the kite to obtain windflow characteristics in rugged terrain. Possible Army applications of the anemometer include wind

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

 410663

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (cont)

measurements to: (1) support electro-optical and high energy laser testing, (2) determine windflows in complex terrain, and (3) detect dangerous, low-level wind shears at military airports.

CONTENTS

1. INTRODUCTION

Wind information is a necessary input to determine how a variety of Army systems will operate in a field environment. Examples of Army systems sensitive to the wind are high energy laser (HEL) systems where crosswind ventilation is essential to prevent excessive heating of the atmosphere along the beam path and other electro-optical (EO) devices where the windfield can determine the distribution of obscurants. It is often necessary in research efforts and in operational support situations to obtain vertical profiles of windspeed and wind direction to substantial heights. To obtain these profiles, use of either tall towers or remote sensors is required. In many cases, these options are not satisfactory because of lack of mobility, high cost, or the complexity of data reduction. For these reasons, there is an ongoing Army interest in alternative methods of wind measurements.

One new instrument for obtaining vertical wind profiles is a kite anemometer named TALA* (tethered aerodynamically lifting anemometer) manufactured by Approach Fish, Incorporated.** This device obtains winds by measuring the force on a kite caused by the wind. It is capable of measuring winds up to altitudes of about 500 m over the range of 3 to 40 ms^{-1}.

The purpose of this research effort was to evaluate the potential usefulness of this kite anemometer to obtain wind profile information for Army applications. The kite was then used to measure wind profiles at a mountaintop location.

2. DESCRIPTION OF THE KITE ANEMOMETER

2.1 Physical Principles

The principle of operation of the kite anemometer is quite simple. The wind exerts a force F on the kite. The force is transmitted through the tether to the ground and then measured at the ground. The windspeed is determined from the force. Theoretically, the force on a flat plate due to a windflow normal to the plate is given by

$$F = 1/2\ C_D\ \rho\ A\ V^2\ , \tag{1}$$

*US patent no 4,058,010 and 4,152,933

**Route 1, Box 620 B, Ringgold, VA 24586, Telephone 804-793-2828 where C_D is a drag coefficient, ρ is the density of air, A is the area, and V is the windspeed. Kite calibration data are very close to the $F \propto V^2$ dependence.[1] These data are described in more detail in section 3.

The altitude z of the kite must be calculated from the length of the tether L and the elevation angle γ of the kite with respect to the ground observer. With measurement of these two parameters, the height of the kite can be calculated from

$$z \cong L \sin \gamma . \tag{2}$$

This formula is only approximate because there is a bow or catenary in the tether. However, Shieh and Frost[2] used a computer model to show that the errors are insignificant. Equation (2) is useful when the ground observer visually measures γ. However, for the purposes of an automated system, the angle that is measured is the angle θ at which the tether intersects the ground. Because of the catenary, $\theta \leq \gamma$. The altitude of the kite is then expressed as

$$z = G(L)\, L \sin \theta , \tag{3}$$

where G(L) is a catenary correction (≥ 1) which is a function of line length. G(L) was empirically determined by the manufacturer and can be significant. For instance, at a line length of $\sim$ 350 m, G(L) $\sim$ 1.2.

2.2 System Components

Figure 1 is a block diagram of the TALA system used in this study. The system used is the most sophisticated (and most expensive) system that is available. The manufacturer offers much less sophisticated (and less expensive) TALA systems.

The heart of the system is the kite which is a very simple airfoil design and is made of Tyvek, a strong but lightweight material. The kite is available in two sizes (1500 cm^2 and 3000 cm^2). A tail is attached to the kite for stability. The smaller kite is able to reach altitudes of 300 m and can withstand winds up to 40 ms^{-1}. The larger kite can reach up to 500 m and

---

[1] J. C. Kaimal, H. W. Baynton, and J. E. Gaynor, 1980, The Boulder Low-Level Intercomparison Experiment, Preprint of World Meteorological Organization report, National Oceanic and Atmospheric Administration/Environmental Research Laboratories, Boulder, CO

[2] C. F. Shieh and W. Frost, 1979, "Tether Analysis for a Kite Anemometer," Wind Engineering, 4:80-86

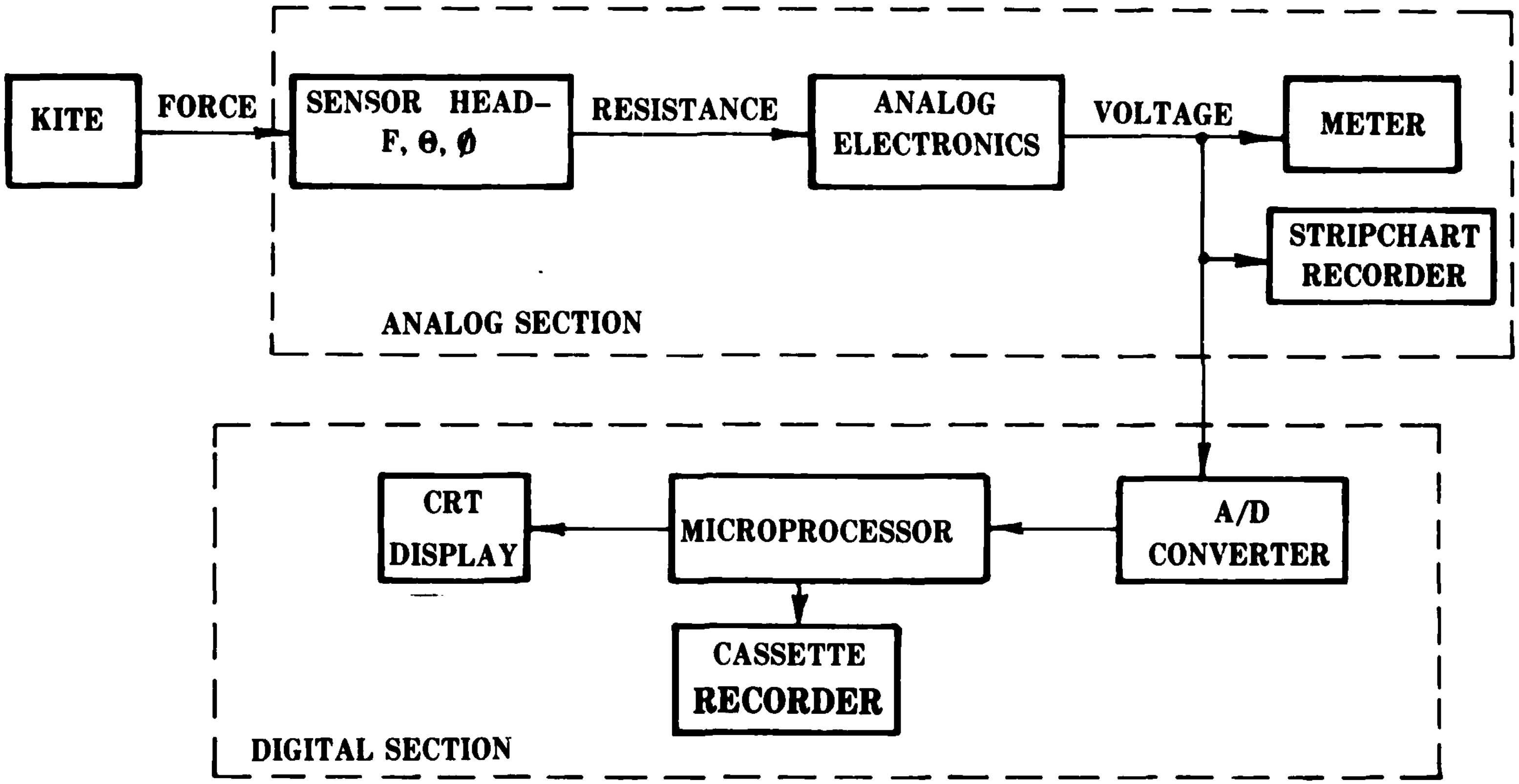


Figure 1. Block diagram of TALA kite anemometer system.

withstand winds of about 25 ms^{-1}. The tether for the kite is made of Kevlar which also is a lightweight (0.25 mm thick) but very strong (30 lb test) material. The tether does not stretch; therefore, the transmission of forces is essentially instantaneous. The tether is attached to a fishing reel which has an attached motor to assist reeling in the kite during high winds.

At the ground, there are a number of options available from the company for measuring the force and recording the data. The most sophisticated option is described here and is labeled as the "analog section" in figure 1.

The force F on the tether is measured by a strain gauge attached to the tether. The strain gauge is mounted on an apparatus (sensor head) which can rotate both in the elevation and the azimuth direction. Potentiometers measure the elevation θ and azimuth ϕ angles of the tether. The azimuth potentiometer is used to sense the horizontal direction of the wind. The elevation potentiometer output together with the length of tether that has been let out is used to calculate the altitude of the kite from equation (3). Two different methods can be used to measure the length of line that has been let out. In one method, a reel counter monitors the number of rotations of the reel. A manufacturer's calibration curve is then used to relate that number to the length of the line. In the second method, a yard counter attached to the tether directly measures the length of line.

Since the strain gauge and potentiometers are resistance elements, analog electronics are used to convert the resistance to electrical voltages. The signals are displayed on a meter and recorded on a strip chart. Power for this analog sensing and recording unit is either an internal Gel cell or an external 12 V dc power supply (for example, car battery).

Data can be measured and recorded with the analog section alone. However, additional sophistication is provided by a digital acquisition system. This system consists of an analog to digital (A/D) converter, a field-programmable microprocessor, a cathode ray tube (CRT) display, and a cassette recorder. The electrical signals from the analog section are digitized by the A/D converter at a rate of 1 Hz. The microprocessor computes windspeed, wind direction, and altitude from the digitized numbers and displays the resulting values on the CRT. Average and standard deviations of these quantities over a specified (by the user) averaging period are stored on cassette tape for later reduction and analysis. The digital system is self-contained and can be run either from an external 12 V dc supply or from a standard 110 V ac outlet.

The entire system is portable and can be carried to a potential site by hand if necessary. The analog section weighs 27 lb and the digital section weighs 28 lb.

Since this system was obtained, a number of improvements have been made in the digital acquisition system. These changes should improve the versatility and ease of use of the system. The major changes are:

a. The cassette recorder has been replaced by a floppy disc drive.

b. The microprocessor has been replaced with a more rugged unit that has been used on off-shore oil platforms.

c. A thermistor, clock, and barometer have been added. These are automatically sampled by the system. Formerly, temperature, time, and pressure had to be input by hand.

d. A 16-channel multiplexer has been added to the A/D converter. Nine channels are reserved for kite data. However, seven channels are available to the user for other purposes and could be used to sample other instruments.

3. EVALUATION

A number of field measurements were made with the kite anemometer in a variety of situations to evaluate the usefulness of the kite for obtaining wind profiles. The following discussion is based on the experience gained in these field tests.

3.1 Operational Characteristics

The kite anemometer can obtain wind measurements up to heights of about 300 m with the smaller kite and 500 m with the larger version. Therefore, the kite has been evaluated with reference to methods of obtaining winds to equivalent heights. These methods include very tall towers and remote sensors. In comparison with these types of systems, the kite anemometer has a number of significant advantages. These advantages include:

a. The kite anemometer is much less expensive than these other methods. The most sophisticated system (described in paragraph 2) costs around $14,000, while the simplest version can be obtained for under $1,000. Constructing tall towers or purchasing remote sensors is much more expensive. In addition, the cost of replacement kites and additional tether line (the parts most likely to be damaged) is very small (for example, $30 for a kite).

b. The device is conceptually simple with little danger of misinterpretation of data. This characteristic is an advantage over remote sensors where noise can be mistakenly identified as signal, and complex mathematical algorithms are often required to obtain wind measurements.

c. The system is portable. It can be hand-carried to a measurement site by one to two people and can be battery operated. It therefore seems ideal for obtaining profiles in remote locations.

d. It is easy to set up. One person can set up the system and begin wind measurements in about 15 minutes.

e. The kite can operate under very windy conditions--up to 40 ms^{-1} for the smaller kite and 25 ms^{-1} for the larger kite.

The disadvantages of the system include:

a. It can obtain only a single point measurement. Therefore winds at different heights cannot be obtained simultaneously. To obtain a wind profile, the kite must be reeled in and out to different heights. Each time the height is changed, the kite must be detached from the sensor head, reeled to a new height, and then reattached to the sensor head--a somewhat cumbersome process. Approximately 30 min are required to obtain a complete profile. This time requirement can result in ambiguities in the interpretation of the resulting profile if the windflow is not stationary. In any experiment, it is suggested that several profiles should be obtained at each location so that nonstationary situations can be identified.

b. The kite will not fly at speeds less than 3 to 4 ms^{-1}. This characteristic requires that the kite be manned at all times since if the wind falls below 3 ms^{-1} the kite will lose altitude and, if left untended, become tangled in surface obstacles such as trees and power lines. In marginal wind situations the kite may not remain at a height long enough to obtain statistically reliable wind averages for that height. The manufacturer claims that balloons attached to the tether can be used to launch the kite under light winds at the surface. Once the desired height is reached, the balloon can be released from the line. However, this is not a general solution since the wind can fluctuate about the minimum flying speed and cause the kite to lose altitude after the balloon has been released from the tether. An additional problem occurs in convective situations with marginal winds where the vertical component of the wind can be significant compared to the horizontal. This situation causes large variations in the altitude of the kite because of large changes in the angle θ in equation (3). The resulting wind vector is thus an average over a large altitude range.

3.2 Calibration

The manufacturer calibrated the kite anemometer in a wind tunnel and states that the kite should measure winds in the atmosphere with 2 percent accuracy. Baker et al[3] compare kite measurements with tower measurements and show an average difference of 2 percent. A more complete study was done at the World Meteorological Organization (WMO) Intercomparison Test[1] which was held during the period of 20 August to 6 September 1979 at the Boulder Atmospheric Observatory (BAO) near Boulder, Colorado, and attended by the author. This test was designed to test a variety of remote and in situ meteorological instruments against standard tower instruments. Approach Fish, Incorporated, participated in this experiment with their kite anemometer. Results of this experiment indicated that kite measurements compared favorably with tower measurements. This comparison is shown in figure 2. When the bad data points are ignored, the kite and tower agree to within 1 m/s. Because of the objective nature of the test, the conclusion is that the kite appears to give accurate measurements of winds. The mean difference seems to be somewhat greater than 2 percent, but this is expected in view of the normal spatial and temporal variability of the wind encountered in the real atmosphere.

---

[3]R. W. Baker, R. L. Whitney, and E. W. Hewson, 1979, "A Low Level Wind Measurement Technique for Wind Turbine Generator Siting," Wind Engineering, 3:107-114

[1]J. C. Kaimal, H. W. Bayton, and J. E. Gaynor, 1980, The Boulder Low-Level Intercomparison Experiment, Preprint of World Meteorological Organization report, National Oceanic and Atmospheric Administration/Environmental Research Laboratories, Boulder, CO

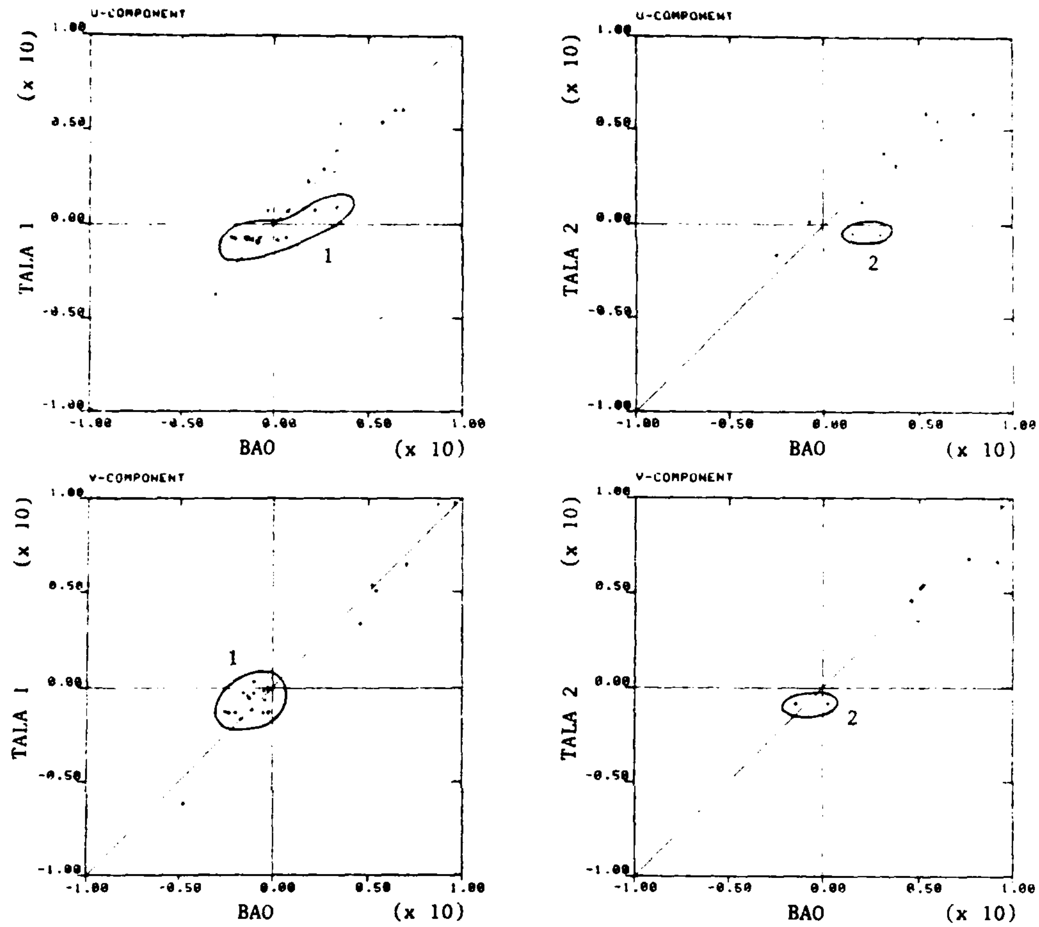


Figure 2. Comparison of TALA winds with tower (BAO) winds. TALA 1 and TALA 2 are similar kites. Data points in group 1 should be discounted because they are only empirical estimates from an uncalibrated lift balloon. Data points in group 2 should be discounted because of equipment malfunction during a thunderstorm (from Kaimal, Baynton, and Gaynor [ref 1]).

The actual calibration of the kite anemometer in a wind tunnel by the manufacturer showed small deviations from the form of equation (1). The following formulas provided a reasonable approximation to the calibration data. The relationship between windspeed and force for the smaller low altitude kite is

$$V = 4.0 \left(\frac{\rho_s}{\rho} \right)^{1/2} F^{0.49} , \qquad (4)$$

where F is in newtons, V is in m/s, ρ is the density of air, and ρ_s is the density of air at standard pressure (sea level) and temperature (59°F). The relationship for the larger high altitude kite is

$$V = \left(\frac{\rho_s}{\rho} \right)^{1/2} [-0.092\ F + 3.86\ F^{1/2} - 2.467] . \qquad (5)$$

4. WIND PROFILE MEASUREMENTS

A series of wind profile measurements was taken with the kite anemometer at a mountaintop location. The mountain is part of a ridge line with a north-south orientation. The west side of the mountain is very steep (average slope approximately 45 degrees), while the east side has a much milder slope (average slope approximately 10 degrees). The mountain peak is approximately 1 km above the surrounding plains. These measurements are not in any way meant to be a comprehensive study of mountain flow patterns. However, they are presented to show the kind of information that the kite anemometer can provide.

A single wind profile consisted of measurements at approximately 50-m-height intervals. At each height the winds were averaged for 2 to 4 min. Two to three min were required to change heights. Therefore, a single profile from near the surface to 250 m required approximately one-half hour.

Figure 3 shows a series of average windspeed profiles. Each profile is a 2- to 3-h average consisting of 4 to 6 single profiles. Two of the profiles (6 November 1979 and 6 February 1980) indicate essentially no vertical gradient in windspeed. The other two (6 December 1979) show a substantial gradient. The cause of this difference is not clear. The gradients on 6 December may be due to drag by the mountain caused by convection. Convection would not have been present for the other profiles because the 6 November profile was taken on a cloudy day and the 6 February profile was taken early in the morning before convection began. Although insufficient supporting measurements were obtained to determine the cause of the differences, these profiles illustrate the ability of the kite to obtain wind profiles at a remote site and to provide information about the different flow conditions that can exist from day to day.

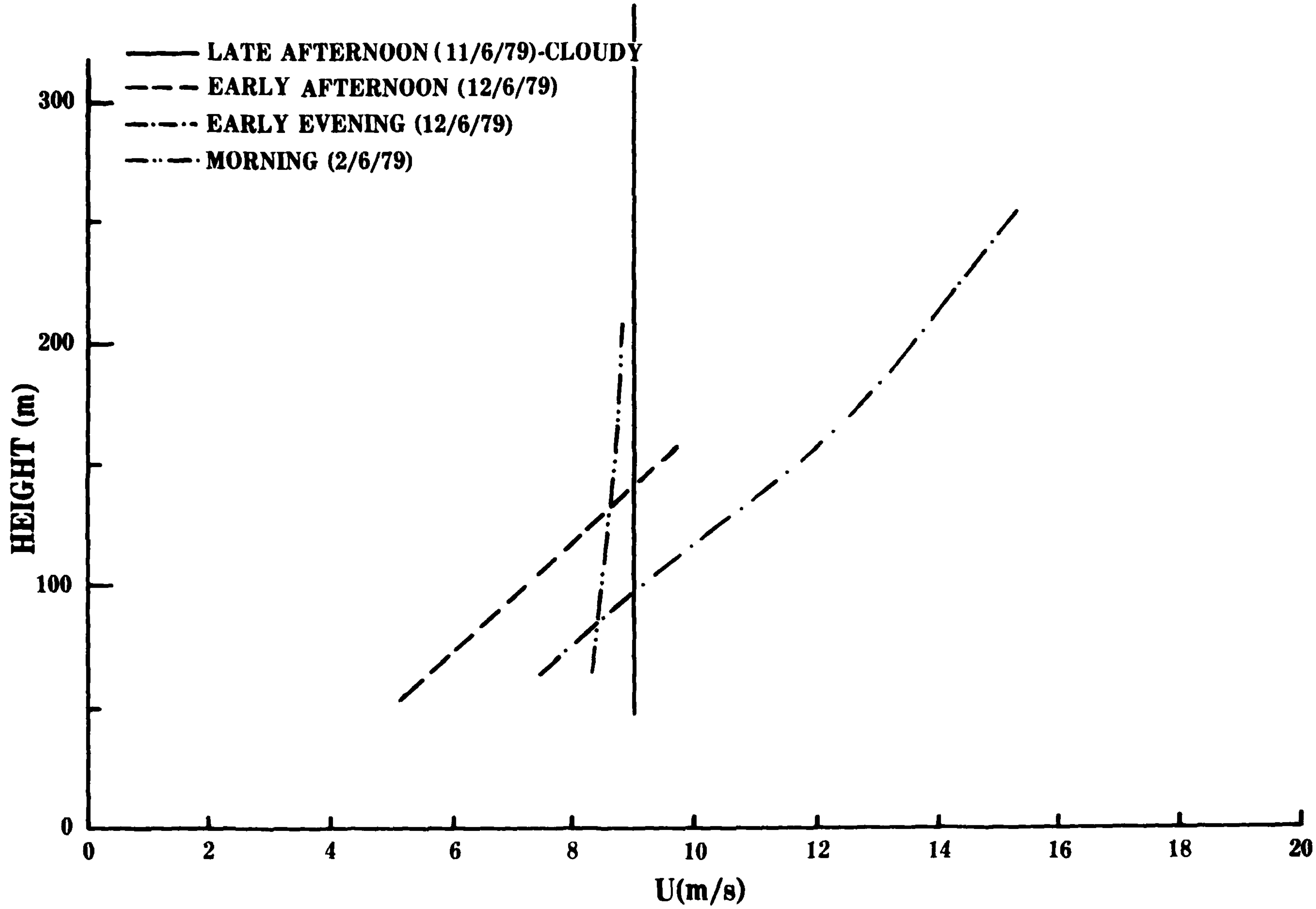


Figure 3. Average wind profiles at a mountaintop location. Each profile is a 2- to 3-h average.

Figure 4 shows the profiles of windspeed and the standard deviation of windspeed for 1500 MST, 24 April 1980. Mostly cloudy conditions were present with strong west winds. The windspeed profile was approximately constant with height with values in the 13 to 16 m/s range. The profile of the standard deviation is quite interesting, showing the large increase in turbulence near the surface. There is an increase of a factor of 3 from the 250-m level down to the 60-m level. This increase corresponds to an increase of a factor of 9 in the turbulent energy of the flow. This difference shows how large an effect a mountain can have on the turbulence in the boundary layer flow. In addition, the standard deviation begins to increase substantially below about 150 m, which suggests that 150 m was approximately the depth of the mountain-induced boundary layer on this day. This profile shows that the kite anemometer can also provide information on the turbulent nature of the flow and on boundary layer depths.

5. POTENTIAL APPLICATIONS OF THE KITE ANEMOMETER

The kite anemometer has been useful in a variety of nonmilitary applications. The most extensive application to date has been its use as a tool in wind power site selection.[3]* Its portability and ability to operate in rugged terrain and in strong winds have made it an inexpensive method to obtain wind profile information at potential wind power sites. The results of the present study indicate that the kite anemometer is a useful and inexpensive method of wind profiling. The unique characteristics of the kite suggest a few possible Army applications. These applications include:

a. Wind profile measurements in support of testing of EO and HEL devices. Much of the testing to date has been done at temporary field locations without tall towers. Future experiments could benefit from the additional measurements provided by the kite. In fact, the data presented in section 4 are being used to characterize a potential HEL testing site.

b. Wind profile measurements in mountainous terrain. The anemometer's portability make it an ideal instrument to use in this application. In particular, it can augment research efforts to determine flow patterns in complex terrain. Such work may lead to a better understanding of diffusion and dispersion of battlefield obscurants in possible combat zones (for example, West Germany and the Middle East) and therefore to an understanding of the potential usefulness of EO devices in combat situations.

c. Profile measurements in support of military airfields. The kite anemometer provides a cheap and safe method of detecting dangerous, low-level wind shears for incoming aircraft. Once again, its portability makes it attractive for use at temporary airfields. Also, since dangerous wind shears

---

[3]R. W. Baker, R. L. Witney, and E. W. Hewson, 1979, "A Low Level Wind Measurement Technique for Wind Turbine Generator Siting," Wind Engineering, 3:107-114

*Personal communication, Steven Keel, sales manager, Approach Fish, Incorporated

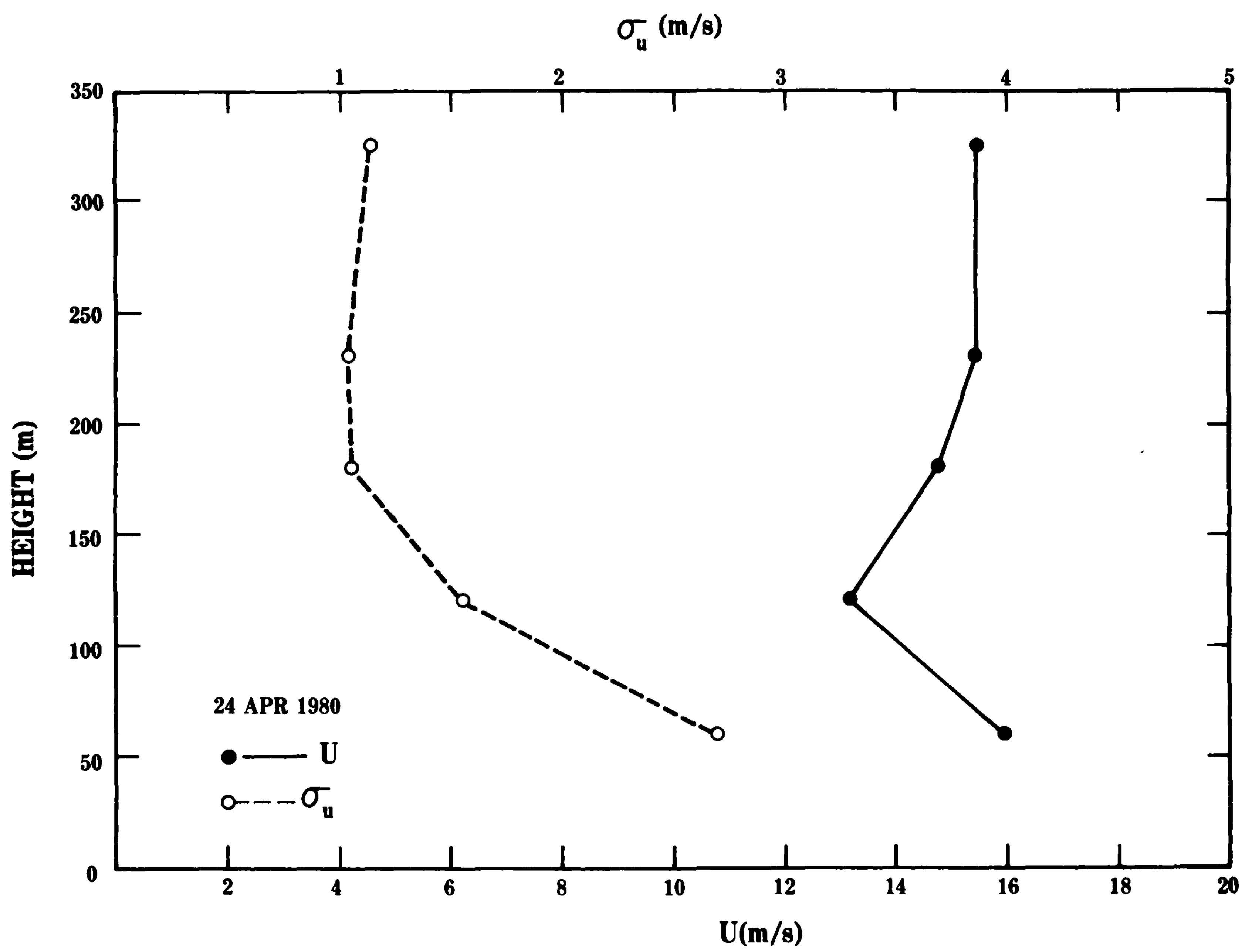


Figure 4. Profiles of windspeed (U) and standard deviation of windspeed (σ_U) for 24 April 1980 at a mountaintop location. The data were obtained at 1500 MST. Each point is an average of 100-200 samples.

occur most frequently under strong wind conditions, the ability of the kite to operate under strong winds is an advantage.

These are just a few of the applications that exist; undoubtedly, the kite anemometer can be useful in a variety of other applications. In general, the kite anemometer may be able to complement or replace tall towers and remote sensors in any Army application where these may be used. The kite anemometer should be considered as an alternative to these other methods because of its economy and other advantages.

ATMOSPHERIC SCIENCES RESEARCH REPORTS

1. Lindberg, J. D., "An Improvement to a Method for Measuring the Absorption Coefficient of Atmospheric Dust and other Strongly Absorbing Powders," ECOM-5565, July 1975.

2. Avara, Elton P., "Mesoscale Wind Shears Derived from Thermal Winds," ECOM-5566, July 1975.

3. Gomez, Richard B., and Joseph H. Pierluissi, "Incomplete Gamma Function Approximation for King's Strong-Line Transmittance Model," ECOM-5567, July 1975.

4. Blanco, A. J., and B. F. Engebos, "Ballistic Wind Weighting Functions for Tank Projectiles," ECOM-5568, August 1975.

5. Taylor, Fredrick J., Jack Smith, and Thomas H. Pries, "Crosswind Measurements through Pattern Recognition Techniques," ECOM-5569, July 1975.

6. Walters, D. L., "Crosswind Weighting Functions for Direct-Fire Projectiles," ECOM-5570, August 1975.

7. Duncan, Louis D., "An Improved Algorithm for the Iterated Minimal Information Solution for Remote Sounding of Temperature," ECOM-5571, August 1975.

8. Robbiani, Raymond L., "Tactical Field Demonstration of Mobile Weather Radar Set AN/TPS-41 at Fort Rucker, Alabama," ECOM-5572, August 1975.

9. Miers, B., G. Blackman, D. Langer, and N. Lorimier, "Analysis of SMS/GOES Film Data," ECOM-5573, September 1975.

10. Manquero, Carlos, Louis Duncan, and Rufus Bruce, "An Indication from Satellite Measurements of Atmospheric CO_2 Variability," ECOM-5574, September 1975.

11. Petracca, Carmine, and James D. Lindberg, "Installation and Operation of an Atmospheric Particulate Collector," ECOM-5575, September 1975.

12. Avara, Elton P., and George Alexander, "Empirical Investigation of Three Iterative Methods for Inverting the Radiative Transfer Equation," ECOM-5576, October 1975.

13. Alexander, George D., "A Digital Data Acquisition Interface for the SMS Direct Readout Ground Station - Concept and Preliminary Design," ECOM-5577, October 1975.

14. Cantor, Israel, "Enhancement of Point Source Thermal Radiation Under Clouds in a Nonattenuating Medium," ECOM-5578, October 1975.

15. Norton, Colburn, and Glenn Hoidale, "The Diurnal Variation of Mixing Height by Month over White Sands Missile Range, NM," ECOM-5579, November 1975.

16. Avara, Elton P., "On the Spectrum Analysis of Binary Data," ECOM-5580, November 1975.

17. Taylor, Fredrick J., Thomas H. Pries, and Chao-Huan Huang, "Optimal Wind Velocity Estimation," ECOM-5581, December 1975.

18. Avara, Elton P., "Some Effects of Autocorrelated and Cross-Correlated Noise on the Analysis of Variance," ECOM-5582, December 1975.

19. Gillespie, Patti S., R. L. Armstrong, and Kenneth O. White, "The Spectral Characteristics and Atmospheric CO_2 Absorption of the Ho^{+3}:YLF Laser at 2.05μm," ECOM-5583, December 1975.

20. Novlan, David J., "An Empirical Method of Forecasting Thunderstorms for the White Sands Missile Range," ECOM-5584, February 1976.

21. Avara, Elton P., "Randomization Effects in Hypothesis Testing with Autocorrelated Noise," ECOM-5585, February 1976.

22. Watkins, Wendell R., "Improvements in Long Path Absorption Cell Measurement," ECOM-5586, March 1976.

23. Thomas, Joe, George D. Alexander, and Marvin Dubbin, "SATTEL - An Army Dedicated Meteorological Telemetry System," ECOM-5587, March 1976.

24. Kennedy, Bruce W., and Delbert Bynum, "Army User Test Program for the RDT&E-XM-75 Meteorological Rocket," ECOM-5588, April 1976.

25. Barnett, Kenneth M., "A Description of the Artillery Meteorological Comparisons at White Sands Missile Range, October 1974 - December 1974 ('PASS' - Prototype Artillery [Meteorological] Subsystem)," ECOM-5589, April 1976.

26. Miller, Walter B., "Preliminary Analysis of Fall-of-Shot From Project 'PASS'," ECOM-5590, April 1976.

27. Avara, Elton P., "Error Analysis of Minimum Information and Smith's Direct Methods for Inverting the Radiative Transfer Equation," ECOM-5591, April 1976.

28. Yee, Young P., James D. Horn, and George Alexander, "Synoptic Thermal Wind Calculations from Radiosonde Observations Over the Southwestern United States," ECOM-5592, May 1976.

29. Duncan, Louis D., and Mary Ann Seagraves, "Applications of Empirical Corrections to NOAA-4 VTPR Observations," ECOM-5593, May 1976.

30. Miers, Bruce T., and Steve Weaver, "Applications of Meteorological Satellite Data to Weather Sensitive Army Operations," ECOM-5594, May 1976.

31. Sharenow, Moses, "Redesign and Improvement of Balloon ML-566," ECOM-5595, June 1976.

32. Hansen, Frank V., "The Depth of the Surface Boundary Layer," ECOM-5596, June 1976.

33. Pinnick, R. G., and E. B. Stenmark, "Response Calculations for a Commerical Light-Scattering Aerosol Counter," ECOM-5597, July 1976.

34. Mason, J., and G. B. Hoidale, "Visibility as an Estimator of Infrared Transmittance," ECOM-5598, July 1976.

35. Bruce, Rufus E., Louis D. Duncan, and Joseph H. Pierluissi, "Experimental Study of the Relationship Between Radiosonde Temperatures and Radiometric-Area Temperatures," ECOM-5599, August 1976.

36. Duncan, Louis D., "Stratospheric Wind Shear Computed from Satellite Thermal Sounder Measurements," ECOM-5800, September 1976.

37. Taylor, F., P. Mohan, P. Joseph, and T. Pries, "An All Digital Automated Wind Measurement System," ECOM-5801, September 1976.

38. Bruce, Charles, "Development of Spectrophones for CW and Pulsed Radiation Sources," ECOM-5802, September 1976.

39. Duncan, Louis D., and Mary Ann Seagraves, "Another Method for Estimating Clear Column Radiances," ECOM-5803, October 1976.

40. Blanco, Abel J., and Larry E. Taylor, "Artillery Meteorological Analysis of Project Pass," ECOM-5804, October 1976.

41. Miller, Walter, and Bernard Engebos, "A Mathematical Structure for Refinement of Sound Ranging Estimates," ECOM-5805, November 1976.

42. Gillespie, James B., and James D. Lindberg, "A Method to Obtain Diffuse Reflectance Measurements from 1.0 and 3.0μm Using a Cary 17I Spectrophotometer," ECOM-5806, November 1976.

43. Rubio, Roberto, and Robert O. Olsen, "A Study of the Effects of Temperature Variations on Radio Wave Absorption," ECOM-5807, November 1976.

44. Ballard, Harold N., "Temperature Measurements in the Stratosphere from Balloon-Borne Instrument Platforms, 1968-1975," ECOM-5808, December 1976.

45. Monahan, H. H., "An Approach to the Short-Range Prediction of Early Morning Radiation Fog," ECOM-5809, January 1977.

46. Engebos, Bernard Francis, "Introduction to Multiple State Multiple Action Decision Theory and Its Relation to Mixing Structures," ECOM-5810, January 1977.

47. Low, Richard D. H., "Effects of Cloud Particles on Remote Sensing from Space in the 10-Micrometer Infrared Region," ECOM-5811, January 1977.

48. Bonner, Robert S., and R. Newton, "Application of the AN/GVS-5 Laser Rangefinder to Cloud Base Height Measurements, ECOM-5812, February 1977.

49. Rubio, Roberto, "Lidar Detection of Subvisible Reentry Vehicle Erosive Atmospheric Material," ECOM-5813, March 1977.

50. Low, Richard D. H., and J. D. Horn, "Mesoscale Determination of Cloud-Top Height: Problems and Solutions," ECOM-5814, March 1977.

51. Duncan, Louis D., and Mary Ann Seagraves, "Evaluation of the NOAA-4 VTPR Thermal Winds for Nuclear Fallout Predictions," ECOM-5815, March 1977.

52. Randhawa, Jagir S., M. Izquierdo, Carlos McDonald, and Zvi Salpeter, "Stratospheric Ozone Density as Measured by a Chemiluminescent Sensor During the Stratcom VI-A Flight," ECOM-5816, April 1977.

53. Rubio, Roberto, and Mike Izquierdo, "Measurements of Net Atmospheric Irradiance in the 0.7- to 2.8-Micrometer Infrared Region," ECOM-5817, May 1977.

54. Ballard, Harold N., Jose M. Serna, and Frank P. Hudson, Consultant for Chemical Kinetics, "Calculation of Selected Atmospheric Composition Parameters for the Mid-Latitude, September Stratosphere," ECOM-5818, May 1977.

55. Mitchell, J. D., R. S. Sagar, and R. O. Olsen, "Positive Ions in the Middle Atmosphere During Sunrise Conditions," ECOM-5819, May 1977.

56. White, Kenneth O., Wendell R. Watkins, Stuart A. Schleusener, and Ronald L. Johnson, "Solid-State Laser Wavelength Identification Using a Reference Absorber," ECOM-5820, June 1977.

57. Watkins, Wendell R., and Richard G. Dixon, "Automation of Long-Path Absorption Cell Measurements," ECOM-5821, June 1977.

58. Taylor, S. E., J. M. Davis, and J. B. Mason, "Analysis of Observed Soil Skin Moisture Effects on Reflectance," ECOM-5822, June 1977.

59. Duncan, Louis D., and Mary Ann Seagraves, "Fallout Predictions Computed from Satellite Derived Winds," ECOM-5823, June 1977.

60. Snider, D. E., D. G. Murcray, F. H. Murcray, and W. J. Williams, "Investigation of High-Altitude Enhanced Infrared Backround Emissions," (U), SECRET, ECOM-5824, June 1977.

61. Dubbin, Marvin H., and Dennis Hall, "Synchronous Meteorological Satellite Direct Readout Ground System Digital Video Electronics," ECOM-5825, June 1977.

62. Miller, W., and B. Engebos, "A Preliminary Analysis of Two Sound Ranging Algorithms," ECOM-5826, July 1977.

63. Kennedy, Bruce W., and James K. Luers, "Ballistic Sphere Techniques for Measuring Atmospheric Parameters," ECOM-5827, July 1977.

64. Duncan, Louis D., "Zenith Angle Variation of Satellite Thermal Sounder Measurements," ECOM-5828, August 1977.

65. Hansen, Frank V., "The Critical Richardson Number," ECOM-5829, September 1977.

66. Ballard, Harold N., and Frank P. Hudson (Compilers), "Stratospheric Composition Balloon-Borne Experiment," ECOM-5830, October 1977.

67. Barr, William C., and Arnold C. Peterson, "Wind Measuring Accuracy Test of Meteorological Systems," ECOM-5831, November 1977.

68. Ethridge, G. A., and F. V. Hansen, "Atmospheric Diffusion: Similarity Theory and Empirical Derivations for Use in Boundary Layer Diffusion Problems," ECOM-5832, November 1977.

69. Low, Richard D. H., "The Internal Cloud Radiation Field and a Technique for Determining Cloud Blackness," ECOM-5833, December 1977.

70. Watkins, Wendell R., Kenneth O. White, Charles W. Bruce, Donald L. Walters, and James D. Lindberg, "Measurements Required for Prediction of High Energy Laser Transmission," ECOM-5834, December 1977.

71. Rubio, Robert, "Investigation of Abrupt Decreases in Atmospherically Backscattered Laser Energy," ECOM-5835, December 1977.

72. Monahan, H. H., and R. M. Cionco, "An Interpretative Review of Existing Capabilities for Measuring and Forecasting Selected Weather Variables (Emphasizing Remote Means)," ASL-TR-0001, January 1978.

73. Heaps, Melvin G., "The 1979 Solar Eclipse and Validation of D-Region Models," ASL-TR-0002, March 1978.

74. Jennings, S. G., and J. B. Gillespie, "M.I.E. Theory Sensitivity Studies - The Effects of Aerosol Complex Refractive Index and Size Distribution Variations on Extinction and Absorption Coefficients, Part II: Analysis of the Computational Results," ASL-TR-0003, March 1978.

75. White, Kenneth O., et al, "Water Vapor Continuum Absorption in the 3.5μm to 4.0um Region," ASL-TR-0004, March 1978.

76. Olsen, Robert O., and Bruce W. Kennedy, "ABRES Pretest Atmospheric Measurements," ASL-TR-0005, April 1978.

77. Ballard, Harold N., Jose M. Serna, and Frank P. Hudson, "Calculation of Atmospheric Composition in the High Latitude September Stratosphere," ASL-TR-0006, May 1978.

78. Watkins, Wendell R., et al, "Water Vapor Absorption Coefficients at HF Laser Wavelengths," ASL-TR-0007, May 1978.

79. Hansen, Frank V., "The Growth and Prediction of Nocturnal Inversions," ASL-TR-0008, May 1978.

80. Samuel, Christine, Charles Bruce, and Ralph Brewer, "Spectrophone Analysis of Gas Samples Obtained at Field Site," ASL-TR-0009, June 1978.

81. Pinnick, R. G., et al., "Vertical Structure in Atmospheric Fog and Haze and its Effects on IR Extinction," ASL-TR-0010, July 1978.

82. Low, Richard D. H., Louis D. Duncan, and Richard B. Gomez, "The Microphysical Basis of Fog Optical Characterization," ASL-TR-0011, August 1978.

83. Heaps, Melvin G., "The Effect of a Solar Proton Event on the Minor Neutral Constituents of the Summer Polar Mesosphere," ASL-TR-0012, August 1978.

84. Mason, James B., "Light Attenuation in Falling Snow," ASL-TR-0013, August 1978.

85. Blanco, Abel J., "Long-Range Artillery Sound Ranging: 'PASS' Meteorological Application," ASL-TR-0014, September 1978.

86. Heaps, M. G., and F. E. Niles, "Modeling of Ion Chemistry of the D-Region: A Case Study Based Upon the 1966 Total Solar Eclipse," ASL-TR-0015, September 1978.

87. Jennings, S. G., and R. G. Pinnick, "Effects of Particulate Complex Refractive Index and Particle Size Distribution Variations on Atmospheric Extinction and Absorption for Visible Through Middle-Infrared Wavelengths," ASL-TR-0016, September 1978.

88. Watkins, Wendell R., Kenneth O. White, Lanny R. Bower, and Brian Z. Sojka, "Pressure Dependence of the Water Vapor Continuum Absorption in the 3.5- to 4.0-Micrometer Region," ASL-TR-0017, September 1978.

89. Miller, W. B., and B. F. Engebos, "Behavior of Four Sound Ranging Techniques in an Idealized Physical Environment," ASL-TR-0018, September 1978.

90. Gomez, Richard G., "Effectiveness Studies of the CBU-88/B Bomb, Cluster, Smoke Weapon," (U), CONFIDENTIAL ASL-TR-0019, September 1978.

91. Miller, August, Richard C. Shirkey, and Mary Ann Seagraves, "Calculation of Thermal Emission from Aerosols Using the Doubling Technique," ASL-TR-0020, November 1978.

92. Lindberg, James D., et al, "Measured Effects of Battlefield Dust and Smoke on Visible, Infrared, and Millimeter Wavelengths Propagation: A Preliminary Report on Dusty Infrared Test-I (DIRT-I)," ASL-TR-0021, January 1979.

93. Kennedy, Bruce W., Arthur Kinghorn, and B. R. Hixon, "Engineering Flight Tests of Range Meteorological Sounding System Radiosonde," ASL-TR-0022, February 1979.

94. Rubio, Roberto, and Don Hoock, "Microwave Effective Earth Radius Factor Variability at Wiesbaden and Balboa," ASL-TR-0023, February 1979.

95. Low, Richard D. H., "A Theoretical Investigation of Cloud/Fog Optical Properties and Their Spectral Correlations, "ASL-TR-0024, February 1979.

96. Pinnick, R. G., and H. J. Auvermann, "Response Characteristics of Knollenberg Light-Scattering Aerosol Counters," ASL-TR-0025, February 1979.

97. Heaps, Melvin G., Robert O. Olsen, and Warren W. Berning, "Solar Eclipse 1979, Atmospheric Sciences Laboratory Program Overview," ASL-TR-0026, February 1979.

98. Blanco, Abel J., "Long-Range Artillery Sound Ranging: 'PASS' GR-8 Sound Ranging Data," ASL-TR-0027, March 1979.

99. Kennedy, Bruce W., and Jose M. Serna, "Meteorological Rocket Network System Reliability," ASL-TR-0028, March 1979.

100. Swingle, Donald M., "Effects of Arrival Time Errors in Weighted Range Equation Solutions for Linear Base Sound Ranging," ASL-TR-0029, April 1979.

101. Umstead, Robert K., Ricardo Pena, and Frank V. Hansen, "KWIK: An Algorithm for Calculating Munition Expenditures for Smoke Screening/Obscuration in Tactical Situations," ASL-TR-0030, April 1979.

102. D'Arcy, Edward M., "Accuracy Validation of the Modified Nike Hercules Radar," ASL-TR-0031, May 1979.

103. Rodriguez, Ruben, "Evaluation of the Passive Remote Crosswind Sensor," ASL-TR-0032, May 1979.

104. Barber, T. L., and R. Rodriguez, "Transit Time Lidar Measurement of Near-Surface Winds in the Atmosphere," ASL-TR-0033, May 1979.

105. Low, Richard D. H., Louis D. Duncan, and Y. Y. Roger R. Hsiao, "Microphysical and Optical Properties of California Coastal Fogs at Fort Ord," ASL-TR-0034, June 1979.

106. Rodriguez, Ruben, and William J. Vechione, "Evaluation of the Saturation Resistant Crosswind Sensor," ASL-TR-0035, July 1979.

107. Ohmstede, William D., "The Dynamics of Material Layers," ASL-TR-0036, July 1979.

108. Pinnick, R. G., S. G. Jennings, Petr Chylek, and H. J. Auvermann, "Relationships between IR Extinction Absorption, and Liquid Water Content of Fogs," ASL-TR-0037, August 1979.

109. Rodriguez, Ruben, and William J. Vechione, "Performance Evaluation of the Optical Crosswind Profiler," ASL-TR-0038, August 1979.

110. Miers, Bruce T., "Precipitation Estimation Using Satellite Data," ASL-TR-0039, September 1979.

111. Dickson, David H., and Charles M. Sonnenschein, "Helicopter Remote Wind Sensor System Description," ASL-TR-0040, September 1979.

112. Heaps, Melvin G., and Joseph M. Heimerl, "Validation of the Dairchem Code, I: Quiet Midlatitude Conditions," ASL-TR-0041, September 1979.

113. Bonner, Robert S., and William J. Lentz, "The Visioceilometer: A Portable Cloud Height and Visibility Indicator," ASL-TR-0042, October 1979.

114. Cohn, Stephen L., "The Role of Atmospheric Sulfates in Battlefield Obscurations," ASL-TR-0043, October 1979.

115. Fawbush, E. J., et al, "Characterization of Atmospheric Conditions at the High Energy Laser System Test Facility (HELSTF), White Sands Missile Range, New Mexico, Part I, 24 March to 8 April 1977," ASL-TR-0044, November 1979.

116. Barber, Ted L., "Short-Time Mass Variation in Natural Atmospheric Dust," ASL-TR-0045, November 1979.

117. Low, Richard D. H., "Fog Evolution in the Visible and Infrared Spectral Regions and its Meaning in Optical Modeling," ASL-TR-0046, December 1979.

118. Duncan, Louis D., et al, "The Electro-Optical Systems Atmospheric Effects Library, Volume I: Technical Documentation," ASL-TR-0047, December 1979.

119. Shirkey, R. C., et al, "Interim E-O SAEL, Volume II, Users Manual," ASL-TR-0048, December 1979.

120. Kobayashi, H. K., "Atmospheric Effects on Millimeter Radio Waves," ASL-TR-0049, January 1980.

121. Seagraves, Mary Ann, and Louis D. Duncan, "An Analysis of Transmittances Measured Through Battlefield Dust Clouds," ASL-TR-0050, February 1980.

122. Dickson, David H., and Jon E. Ottesen, "Helicopter Remote Wind Sensor Flight Test," ASL-TR-0051, February 1980.

123. Pinnick, R. G., and S. G. Jennings, "Relationships Between Radiative Properties and Mass Content of Phosphoric Acid, HC, Petroleum Oil, and Sulfuric Acid Military Smokes," ASL-TR-0052, April 1980.

124. Hinds, B. D., and J. B. Gillespie, "Optical Characterization of Atmospheric Particulates on San Nicolas Island, California," ASL-TR-0053, April 1980.

125. Miers, Bruce T., "Precipitation Estimation for Military Hydrology," ASL-TR-0054, April 1980.

126. Stenmark, Ernest B., "Objective Quality Control of Artillery Computer Meteorological Messages," ASL-TR-0055, April 1980.

127. Duncan, Louis D., and Richard D. H. Low, "Bimodal Size Distribution Models for Fogs at Meppen, Germany," ASL-TR-0056, April 1980.

128. Olsen, Robert O., and Jagir S. Randhawa, "The Influence of Atmospheric Dynamics on Ozone and Temperature Structure," ASL-TR-0057, May 1980.

129. Kennedy, Bruce W., et al, "Dusty Infrared Test-II (DIRT-II) Program," ASL-TR-0058, May 1980.

130. Heaps, Melvin G., Robert O. Olsen, Warren Berning, John Cross, and Arthur Gilcrease, "1979 Solar Eclipse, Part I - Atmospheric Sciences Laboratory Field Program Summary," ASL-TR-0059, May 1980

131. Miller, Walter B., "User's Guide for Passive Target Acquisition Program Two (PTAP-2)," ASL-TR-0060, June 1980.

132. Holt, E. H., H. H. Monahan, and E. J. Fawbush, "Atmospheric Data Requirements for Battlefield Obscuration Applications," ASL-TR-0061, June 1980.

133. Shirkey, Richard C., August Miller, George H. Goedecke, and Yugal Behl, "Single Scattering Code AGAUSX: Theory, Applications, Comparisons, and Listing," ASL-TR-0062, July 1980.

134. Sojka, Brian Z., and Kenneth O. White, "Evaluation of Specialized Photoacoustic Absorption Chambers for Near-Millimeter Wave (NMMW) Propagation Measurements," ASL-TR-0063, August 1980.

135. Bruce, Charles W., Young Paul Yee, and S. G. Jennings, "In Situ Measurement of the Ratio of Aerosol Absorption to Extinction Coefficient," ASL-TR-0064, August 1980.

136. Yee, Young Paul, Charles W. Bruce, and Ralph J. Brewer, "Gaseous/Particulate Absorption Studies at WSMR using Laser Sourced Spectrophones," ASL-TR-0065, June 1980.

137. Lindberg, James D., Radon B. Loveland, Melvin Heaps, James B. Gillespie, and Andrew F. Lewis, "Battlefield Dust and Atmospheric Characterization Measurements During West German Summertime Conditions in Support of Grafenwohr Tests," ASL-TR-0066, September 1980.

138. Vechione, W. J., "Evaluation of the Environmental Instruments, Incorporated Series 200 Dual Component Wind Set," ASL-TR-0067, September 1980.

139. Bruce, C. W., Y. P. Yee, B. D. Hinds, R. G. Pinnick, R. J. Brewer, and J. Minjares, "Initial Field Measurements of Atmospheric Absorption at 9μm to 11μm Wavelengths," ASL-TR-0068, October 1980.

140. Heaps, M. G., R. O. Olsen, K. D. Baker, D. A. Burt, L. C. Howlett, L. L. Jensen, E. F. Pound, and G. D. Allred, "1979 Solar Eclipse: Part II Initial Results for Ionization Sources, Electron Density, and Minor Neutral Constituents," ASL-TR-0069, October 1980.

141. Low, Richard D. H., "One-Dimensional Cloud Microphysical Models for Central Europe and their Optical Properties," ASL-TR-0070, October 1980.

142. Duncan, Louis D., James D. Lindberg, and Radon B. Loveland, "An Empirical Model of the Vertical Structure of German Fogs," ASL-TR-0071, November 1980.

143. Duncan, Louis D., 1981, "EOSAEL 80, Volume I, Technical Documentation," ASL-TR-0072, January 1981.

144. Shirkey, R. C., and S. G. O'Brien, "EOSAEL 80, Volume II, Users Manual," ASL-TR-0073, January 1981.

145. Bruce, C. W., "Characterization of Aerosol Nonlinear Effects on a High-Power CO_2 Laser Beam", ASL-TR-0074 (Draft), February 1981.

146. Duncan, Louis D., and James D. Lindberg, "Air Mass Considerations in Fog Optical Modeling," ASL-TR-0075, February 1981.

147. Kunkel, Kenneth E., "Evaluation of a Tethered Kite Anemometer," ASL-TR-0076, February 1981.

DISTRIBUTION LIST

Commander
US Army Aviation Center
ATTN: ATZQ-D-MA
Fort Rucker, AL 36362

Chief, Atmospheric Sciences Div
Code ES-81
NASA
Marshall Space Flight Center, AL 35812

Commander
US Army Missile Command
ATTN: DRDMI-RRA/Dr.O. M. Essenwanger
Redstone Arsenal, AL 35809

Commander
US Army Missile Command
ATTN: DRSMI-OG (B. W. Fowler)
Redstone Arsenal, AL 35809

Commander
US Army Missile R&D Command
ATTN: DRDMI-TEM (R. Haraway)
Redstone Arsenal, AL 35809

Redstone Scientific Information Center
ATTN: DRSMI-RPRD (Documents)
US Army Missile Command
Redstone Arsenal, AL 35809

Commander
HQ, Fort Huachuca
ATTN: Tech Ref Div
Fort Huachuca, AZ 85613

Commander
US Army Intelligence
Center & School
ATTN: ATSI-CD-MD
Fort Huachuca, AZ 85613

Commander
US Army Yuma Proving Ground
ATTN: Technical Library
Bldg 2105
Yuma, AZ 85364

Dr. Frank D. Eaton
Geophysical Institute
University of Alaska
Fairbanks, AK 99701

Naval Weapons Center
Code 3918
ATTN: Dr. A. Shlanta
China Lake, CA 93555

Commanding Officer
Naval Envir Prediction Rsch Facility
ATTN; Library
Monterey, CA 93940

Sylvania Elec Sys Western Div
ATTN: Technical Reports Lib
PO Box 205
Mountain View, CA 94040

Geophysics Officer
PMTC Code 3250
Pacific Missile Test Center
Point Mugu, CA 93042

Commander
Naval Ocean Systems Center
(Code 4473)
ATTN: Technical Library
San Diego, CA 92152

Meteorologist in Charge
Kwajalein Missile Range
PO Box 67
APO San Francisco, CA 96555

Director
NOAA/ERL/APCL R31
RB3-Room 567
Boulder, CO 80302

Dr.B. A. Silverman D-1200
Office of Atmos Resources Management
Water and Power Resources Service
PO Box 25007Denver Federal Center, Bldg. 67
Denver, CO 80225

Hugh W. Albers (Executive Secretary)
CAO Subcommittee on Atmos Rsch
National Science Foundation Room 510
Washington, DC 2055

Dr. Eugene W. Bierly
Director, Division of Atmos Sciences
National Scinece Foundation
1800 G Street, N.W.
Washington, DC 20550

Commanding Officer
Naval Research Laboratory
Code 2627
Washington, DC 20375

Defense Communications Agency
Technical Library Center
Code 222
Washington, DC 20305

Director
Naval Research Laboratory
Code 5530
Washington, DC 20375

Dr. J. M. MacCallum
Naval Research Laboratory
Code 1409
Washington, DC 20375

HQDA (DAEN-RDM/Dr. de Percin)
Washington, DC 20314

The Library of Congress
ATTN: Exchange & Gift Div
Washington, DC 20540
2

Mil Asst for Atmos Sci Ofc of
the Undersecretary of Defense
for Rsch & Engr/E&LS - RM 3D129
The Pentagon
Washington, DC 20301

AFATL/DLODL
Technical Library
Eglin AFB, FL 32542

Naval Training Equipment Center
ATTN: Technical Information Center
Orlando, FL 32813

Technical Library
Chemical Systems Laboratory
Aberdeen Proving Ground, MD 21010

US Army Materiel Systems
Analysis Activity
ATTN: DRXSY-MP
APG, MD 21005

Commander
ERADCOM
ATTN: DRDEL-PA/ILS/-ED
2800 Powder Mill Road
Adelphi, MD 20783

Commander
ERADCOM
ATTN: DRDEL-ST-T (Dr. B. Zarwyn)
2800 Powder Mill Road
Adelphi, MD 20783
02

Commander
Harry Diamond Laboratories
ATTN: DELHD-CO
2800 Powder Mill Road
Adelphi, MD 20783

Chief
Intel Mat Dev & Spt Ofc
ATTN: DELEW-WL-I
Bldg 4554
Fort George G. Mead, MD 20755

Acquisitions Section, IRDB-D823
Library & Info Svc Div, NOAA
6009 Executive Blvd.
Rockville, MD 20752

Naval Surface Weapons Center
White Oak Library
Silver Spring, MD 20910

Air Force Geophysics Laboratory
ATTN: LCC (A. S. Carten, Jr.)
Hanscom AFB, MA 01731

Air Force Geophysics Laboratory
ATTN: LYD
Hanscom AFB, MA 01731

Meteorology Division
AFGL/LY
Hanscom AFB, MA 01731

The Environmental Research
Institute of MI
ATTN: IRIA Library
PO Box 8618
Ann Arbor, MI 48107

Mr. William A. Main
USDA Forest Service
1407 S. Harrison Road
East Lansing, MI 48823

Dr. A. D. Belmont
Research Division
PO Box 1249
Control Data Corp
Minneapolis, MN 55440

Commander
Naval Oceanography Command
Bay St. Louis, MS 39529

Commanding Officer
US Army Armament R&D Command
ATTN; DRDAR-TSS Bldg 59
Dover, NJ 07801

Commander
ERADCOM Scientific Advisor
ATTN: DRDEL-SA
Fort Monmouth, NJ 07703

Commander
ERADCOM Tech Support Activity
ATTN: DELSD-L
Fort Monmouth, NJ 07703

Commander
HQ, US Army Avionics R&D Actv
ATTN: DAVAA-O
Fort Monmouth, NJ 07703

Commander
USA Elect Warfare Lab
ATTN: DELEW-DA (File Cy)
Fort Monmouth, NJ 07703

Commander
US Army Electronics R&D Command
ATTN: DELCS-S
Fort Monmouth, NJ 07703

Commander
US Army Satellite Comm Agency
ATTN: DRCPM-SC-3
Fort Monmouth, NJ 07703

Commander/Director
US Army Combat Survl & Target
Acquisition Laboratory
ATTN: DELCS-D
Fort Monmouth, NJ 07703

Director
Night Vision & Electro-Optics Laboratory
ATTN: DELNV-L (Dr. R. Buser)
Fort Belvoir, VA 22060

Project Manager, FIREFINDER
ATTN: DRCPM-FF
Fort Monmouth, NJ 07703

PM, Firefinder/REMBASS
ATTN: DRCPM-FFR-TM
Fort Monmouth, NJ 07703

6585 TG/WE
Holloman AFB, NM 88330

AFWL/Technical Library (SUL)
Kirtland AFB, NM 87117

AFWL/WE
Kirtland, AFB, NM 87117

TRASANA
ATTN: ATAA-SL (D. Anguiano)
WSMR, NM 88002

Commander
US Army White Sands Missile Range
ATTN: STEWS-PT-AL
White Sands Missile Range, NM 88002

Rome Air Development Center
ATTN: Documents Library
TSLD (Bette Smith)
Griffiss AFB, NY 13441

Environmental Protection Agency
Meteorology Laboratory, MD 80
Rsch Triangle Park, NC 27711

US Army Research Office
ATTN: DRXRO-PP
PO Box 12211
Rsch Triangle Park, NC 27709

Commandant
US Army Field Artillery School
ATTN: ATSF-CD-MS (Mr. Farmer)
Fort Sill, OK 73503

Commandant
US Army Field Artillery School
ATTN: ATSF-CF-R
Fort Sill, OK 73503

Commandant
US Army Field Artillery School
ATTN: Morris Swett Library
Fort Sill, OK 73503

Commander
US Army Dugway Proving Ground
ATTN: STEDP-MT-DA-M
(Mr. Paul Carlson)
Dugway, UT 84022

Commander
US Army Dugway Proving Ground
ATTN: MT-DA-L
Dugway, UT 84022

US Army Dugway Proving Ground
ATTN: STEDP-MT-DA-T
(Dr. W. A. Peterson)
Dugway, UT 84022

Inge Dirmhirn, Professor
Utah State University, UMC 48
Logan, UT 84322

Defense Technical Information Center
ATTN: DTIC-DDA-2
Cameron Station, Bldg. 5
Alexandria, VA 22314
12

Commanding Officer
US Army Foreign Sci & Tech Cen
ATTN: DRXST-IS1
220 7th Street, NE
Charlottesville, VA 22901

Naval Surface Weapons Center
Code G65
Dahlgren, VA 22448

Commander
US Army Night Vision
& Electro-Optics Lab
ATTN: DELNV-D
Fort Belvoir, VA 22060

Commander
USATRADOC
ATTN: ATCD-FA
Fort Monroe, VA 23651

Commander
USATRADOC
ATTN: ATCD-IR
Fort Monroe, VA 23651

Dept of the Air Force
5WW/DN
Langley AFB, VA 23665

US Army Nuclear & Cml Agency
ATTN: MONA-WE
Springfield, VA 22150

Director
US Army Signals Warfare Lab
ATTN: DELSW-OS (Dr. Burkhardt)
Vint Hill Farms Station
Warrenton, VA 22186

Commander
US Army Cold Regions Test Cen
ATTN: STECR-OP-PM
APO Seattle, WA 98733

ATE
LMED
8